Title: What *"Ohm's"* You?

Brief Overview:

This lesson is designed to help students learn to use the CBL and the Voltage Probe. Using the CBL, TI-82, and Voltage Probe, students will see the discharge of voltage over time through their body. This can lead to discussions on Ohm's Law, Kirchhoff's Rules, resistors, capacitors, exponential equations, and basic algebraic equations.

Link to Standards:

- **Problem Solving** — Students will calculate the resistance in ohms of their bodies.
- **Connection** — Students will learn the relationship between an exponential curve (math) and resistance (physics).
- **Number Relationships** — Students will see that numbers do have a place in the real world specifically in the measurement of voltage, resistance, and current.
- **Algebra** — Students will apply their knowledge of base e, natural logs, exponential curves, and solving exponential equations.

Grade/Level:

Grades 10-12

Duration/Length:

This activity will take 1 or 2 class periods to complete.

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Use of the TI-82
- Solving exponential equations
- Using *e* and *ln*
- Graphing exponential curves

Objectives:

Students will be able to:

- work cooperatively in groups.
- collect and organize data from CBL, TI-82, and Voltage Probe.
- analyze graphs and calculated values to make real-world conclusions about voltage and resistance.

Materials/Resources/Printed Materials:

- TI-82, CBL, Voltage Probe
- 9V battery, 100mfd capacitor
- Student worksheet
- Teacher resources

Development/Procedures:

- Lab Set Up:
    1. Download the OHMS program to the TI-82.
    2. Link the CBL and the TI-82, plug the Voltage Probe into the channel 1 port, connect the 9 volt battery, and capacitor as shown in the diagram on the student lab worksheet.
    3. Clear the TI-82 calculator in the Y = menu.
    4. Turn on the CBL unit and the calculator. Follow the directions given in the student worksheet.
- Lab Introduction
    1. Show students the equipment, explaining how it is going to be used.
    2. Follow the directions on the student worksheet.

Evaluation:

The student should complete the worksheet and conclude with his/her resistance value. In addition, the student should list real-world conclusions about his/her graphs and why the differences in fellow student curves. The hope is to help the student discover that the higher the resistance the slower the current, thus the slower the loss of voltage or vice versa.

Authors:

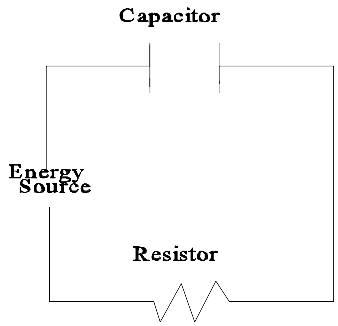
Joanne Rowe
Cox High School
Virginia Beach, VA

Jeff Shoaf
Cox High School
Virginia Beach, VA

Jim Bryan
Salem High School
Virginia Beach, VA

STUDENT WORKSHEET

A circuit containing a resistor and a capacitor is called an **RC circuit**.

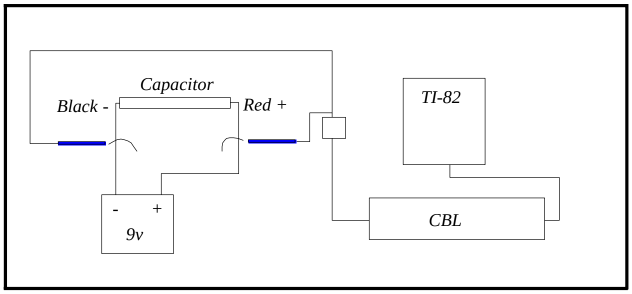


A **capacitor** is an electrical component used to store energy and charge.

A **resistor** is an electrical component used to restrict the flow of charge from the capacitor.

In this lab, you will be using the CBL, TI-82, 9-volt battery, and the voltage probe to collect voltage data from a discharging 100 mfd (microfarad) electrolytic capacitor. The capacitor will be held by your fingertips and you will become the resistor, which is used to control the rate at which the capacitor discharges. The voltage data you collect will be analyzed so that we can develop a mathematical model to describe the resulting curve.

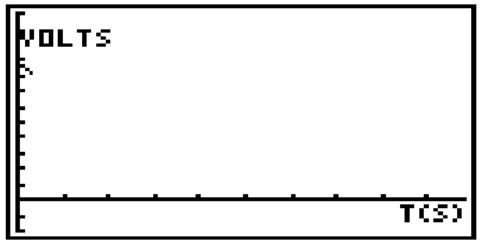
STEP 1:
Connect the capacitor, voltage probe, CBL, TI-82, and the 9-volt battery as shown.



Note: In order to get an accurate measure of your resistance (measured in ohms) we must first calculate the resistance of the CBL and the attached voltage probe.

STEP 2:
Holding the capacitor cylinder, charge the capacitor with the 9-volt battery making sure the red connector goes to the + terminal and the black to the - terminal. This will take only a few seconds. Begin the DCHARGE program which is a variation of the CHARGE program found in the Texas Instruments Real-World Math with the CBL System workbook.

A. Sketch the graph.

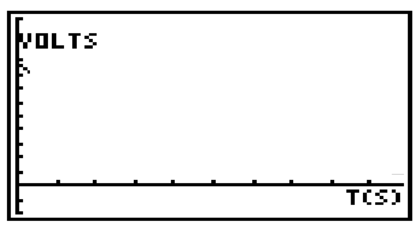


B. Describe the curve:__________ __________________
____
____
____

C. What is the initial voltage?_________
D. What is the final voltage? _________
E. How much time elapsed? _________

STEP 3:
Re-charge the capacitor but this time hold the capacitor wires, one in each hand, and start the DCHARGE program.

A. Sketch the graph.



B. What is the initial voltage?________
C. What is the final voltage?________

NOTE: From your graph you can see that the rate of decrease is not constant (meaning linear), but also decreases with time forming a decreasing exponential curve that is frequently found in nature. It occurs when the rate at which an amount decreases is proportional to the amount itself. This discharging capacitor models the following equation:

$$\mathbf{y = Ve^{-x/RC}}$$

x = time
y = voltage from the capacitor at any time
e = base of the natural logarithmic function
V= initial voltage reading from the capacitor
R= resistance (ohms)
C= capacitance (in farads) *1mfd = 10^{-6} farads

STEP 4:
To calculate your resistance you need to find:

CBL		COMBINED
y = ______	(Final voltage reading)	y = ______
V = _____	(Initial voltage reading)	V = _____
x = ______	(Time of the experiment)	x = ______
C = _____	(Our capacitor was 100 mfd) *Remember to convert to farads.	C = _____

Use the equation: $\mathbf{y = Ve^{-x/RC}}$ and solve for R_{CBL} and $R_{COMBINED}$.

R_{CBL} = ________________ (Resistance in ohms) $R_{COMBINED}$ = __________________

Ohm's Law states that the voltage drop across a resistor varies directly with the current:

$$\mathbf{V = I \cdot R}$$

By applying Ohm's Law and Kirchhoff's Rules we can obtain an equation that can be used to calculate your resistance:

$$YOUR\ \ RESISTANCE = \frac{R_{CBL} \cdot R_{COMBINED}}{R_{CBL} - R_{COMBINED}}$$

YOUR RESISTANCE = ________________________

STEP 5:

A. Compare the resistance values of other members in your group. How do these values effect the voltage?____

B. Why are these **resistance** values different?____________________________________

STEP 6:
We will now attempt to fit our information to a curve using the exponential equation given earlier: $\mathbf{y = Ve^{-x/RC}}$ where y is the voltage in the capacitor and x is the time.
Press **Y=** and enter the expression: $\mathbf{Ve^{-x/RC}}$.   Press the **TRACE** key which will allow us to identify the y-intercept. Record this value:________.   What does this value represent? __________
____
To save this value: press **2nd   QUIT   ALPHA   Y   STO   ALPHA   V   ENTER.**
Now press $\mathbf{100 \times 10^{-6}}$ **STO ALPHA   C   ENTER.**
We will need to substitute different values for R to match your voltage curve. This value of R is the combination of your resistance and the CBL's .   Try **1,000,000   STO   ALPHA R ENTER .**   Press   **GRAPH**   to show the data and our exponential equation on the viewscreen. Continue to try different numbers for the variable R by repeating this last step.
Record you best R:__________________.

Therefore, your final equation that models the given data is:

y =___________________.

Extension:
List real-world conclusions about the graphs and why there are differences in fellow student curves.

OHMS PROGRAM

```
\START82\
\COMMENT=Program file dated 08/01/95, 2004
\NAME=OHMS
\FILE=OHMS.82P
Fullscreen
PlotsOff
Func
AxesOn
ClrHome
Disp “CONNECT + & -”
Disp “TERMINALS OF”
Disp “VOLTAGE PROBE”
Disp “TO CAPACITOR”
Output(8,10,”[ENTER]”)
Pause
ClrHome
Disp “TOUCH + and -”
Disp “CAPACITOR LEADS”
Disp “TO THE TERMINALS”
Disp “OF THE BATTERY”
Disp “”
Disp “HOLD IN PLACE.”
Output(8,1,”[ENTER]”)
Pause
AxesOn
-2\->\Ymin
12\->\Ymax
1\->\Yscl
0\->\Xmin
99\->\Xmax
10\->\Xscl
ClrHome
{1,0}\->\\L1\
Send(\L1\)
{1,1,1}\->\\L1\
send(\L1\)
00\->\dim \L2\
Clrhome
Disp “REMOVE CAPACITOR”
Disp “FROM BATTERY AND”
Disp “PRESS [ENTER]”
Disp “SIMULTANEOUSLY”
Disp “TO START”
```

```
Pause
clrHome
ClrList \L1\,\L2\
99\->\dim \L2\
ClrDraw
{3,.5,-1,0}\->\\L1\
send(\L1\)
Text(4,1,“VOLTS”)TEXT(54,81,“T(S)”)
FOR(I,1,99,1)
Get(\L2\(I))
abs \L2\(I)\->\\L2\(I)
pt-On(I,\L2\(I))
end
.5*seq(N<N<0,98,1)\->\\L1\
5\->\Xscl
0\->\Xmin
max(L)\->\Xmax
-2\->\Ymin
12\->\Ymax
1\->\Yscl
ClrList \L3\,\L4\,\L5\,\L6\
Plot1(Scatter,\L1\,\L2\,\dot icon\)
DispGraph
Text(4,1,”VOLTS”)Text(54,81,”T(S)”)
0\->\U
0\->\V
StoreGDB GDB6
Stop
\STOP82\
```